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# Speech cine SSFP with optical microphone synchronization and motion compensated reconstruction

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## PURPOSE

Dynamic imaging of the vocal tract is important for modeling speech through the acoustic-articulatory relation.

Previous work:

- X-ray video fluoroscopy : ionizing radiation;
- Real-time MRI [1]: limited SNR and spatial resolution;
- Cine MRI with acoustic device gating [2]: needs highly reproducible motion.

This work:

- Ungated acquisition with acoustic device recording;
- Motion-compensated cine reconstruction.

## MATERIAL & METHODS

### ➤ Data acquisition

- Ungated balanced SSFP: 1 sagittal slice, 256x256 matrix, TR/TE=3.9/1.7 ms, 5 mm slice thickness, 45° flip angle, 30 cm FOV, 65 temporal phases, approx. 1 min acquisition duration.
- The subject was asked to repeat a sentence until the sequence stopped. The protocol comprised 10 short sentences providing a good coverage of the tongue movement in French language [3].
- Acoustic signal recording using an optical microphone (FOMRI III, Optoacoustics, Yehuda Israel). The scanner's acquisition window signal was also recorded by the device for synchronization with MR data.

### ➤ Acoustic signal processing

- Denoising of acoustic signals [4] to eliminate gradient noise;
- Phonetic segmentation to annotate the beginning of each phoneme ;
- Creation of an acoustic phase signal to indicate the temporal position of each k-space sample in the sentence

### ➤ Cine image reconstruction

- Piecewise linear scaling is used to combine all occurrences of a sentence based on the manual segmentation of the acoustic signals.
- Motion-corrected sliding window reconstruction using cine-GRICS [5]: a sliding window of 50 ms was chosen and a template sentence is reconstructed with 128 frames (temporal resolution <10 ms).

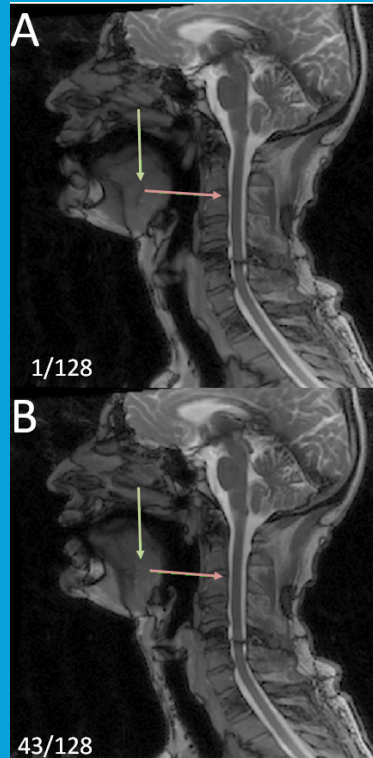


Fig.1 A sagittal slice with two time frames (A) and (B) from a reconstructed template sentence cine loop.

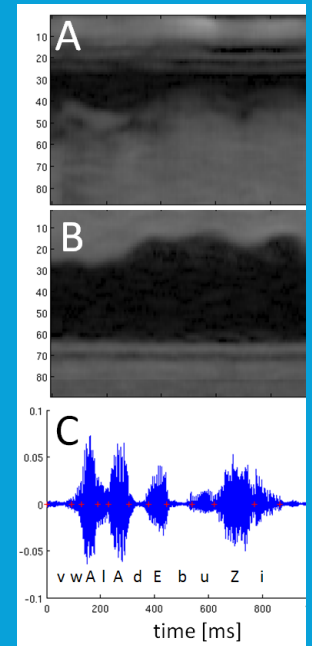


Fig.2 Time-motion display of the cine loop for (A) hard palate to tongue dorsum and (B) tongue back to pharyngeal wall; (C) the corresponding sound signal with manual annotations of phonemes (red crosses).

## RESULTS

- Efficient gating and artifact suppression as illustrated in Fig. 1 with two images of the subject pronouncing "Voilà des bougies".
- Characteristic distances can be measured over time such as those between the tongue dorsum and the hard palate or between the tongue back and the pharyngeal wall (see Fig. 2).

## DISCUSSION AND CONCLUSION

- A limitation of the balanced SSFP sequence is the possible banding artifacts due to the strong Bo gradient at the air tissue interface.
- Each cine loop enables the delineation of the vocal tract with sufficient spatial and temporal resolution enabling the acquisition of a personalized speech model within an MR examination of half an hour.

## REFERENCES

- [1] Narayanan et al., J Acoust Soc Am, 115(4):1771 (2004) ; [2] Frauenrath et al., Act Acus, 94(1):148 (2008);  
[3] Maeda, Actes X JEP, p152, Grenoble (1979) ; [4] Ozerov et al., IEEE TASLP, 20(4) :1118 (2012); [5] Vuissoz et al., JMRI, 35 :340 (2012).